

Original Article

Relationship of the changes of cervical MRI, TCD and BAEP in patients with “isolated” vertigo

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Received June 6, 2014; Accepted July 23, 2014; Epub July 15, 2014; Published August 1, 2014

Abstract: Objective: To study the relationship and changes of cervical MRI, TCD and BAEP in patients with “isolated” vertigo. Methods: The relationship and changes of cervical MRI, TCD and BAEP were investigated respectively in 125 patients with “isolated” vertigo and 100 healthy controls. Results: There were statistically significant differences between two groups for overall abnormalities of TCD ($\chi^2 = 61.96$, $P < 0.01$), BAEP ($\chi^2 = 97.99$, $P < 0.01$), and cervical MRI severity scale ($Z = -8.71$, $P < 0.01$). In vertigo group, results showed significant correlations between TCD and cervical MRI, TCD and BAEP as well. And analysis on TCD PI and some items of BAEP demonstrated positive linear correlations. There were no statistical differences or correlations in control group. Conclusions: TCD is a sensitive method of “isolated” vertigo screening. A combined test protocol of cervical MRI, TCD and BAEP has superiorities to assess “isolated” vertigo.

Keywords: Vertigo, cervical spondylosis, MRI, transcranial Doppler, brain auditory evoked potential

Introduction

Vertigo is a symptomatology conception associated with multiple systems, including cervico-cephalic movements, vestibular (inner ear), visual, vascular, neurovascular, cervical proprioceptive, and cervical spinal cord dysfunction. Nearly 50% of patients with dizziness mean to experience vertigo [1, 2]. However, due to the lack of specific diagnostic tests, vertigo often overlaps with other diagnosis that also has no specific tests. And “isolated” vertigo [3] seems to be more complex, if neurologic examination and head MRI are both negative. Some vertigo may result in brainstem or cerebellum stroke, and that will profoundly influence the patient [3]. Kerber et al. [4] reported that, patients with an “isolated” symptom of dizziness had a low prevalence of stroke (0.7%), but patients with combined symptoms of dizziness, vertigo, and imbalance had a high prevalence of stroke (3.2%). Norrving et al [5]. reported that elderly patients with acute episodic vertigo had a higher prevalence rate of stroke (12.5%). Although the higher occurrence of stroke in Norrving's study may partly attribute to age effect, which is another risk factor for stroke, it

hints that a highly sensitive and specific test protocol for primary prevention of stroke should be used on patients complaining of vertigo in age of stroke onset. This article reports changes of cervical MRI, TCD and BAEP in patients with “isolated” vertigo, and arouses close attention to primary prevention of stroke.

Materials and methods

Participants

125 patients complaining of transient vertigo with head CT/MRI negative were recruited from the inpatient clinic of neurology department of our hospital between May 2013 and December 2013, including 67 males and 58 females, with mean age 58.1 ± 7.3 years. 100 healthy controls matched in sex and age were all from physical examination department during the same time, and among them were 53 males and 47 females, with mean age 55.8 ± 5.3 years.

Enrollment and exclusion

Inclusion criteria: Diagnosis criteria of transient vertigo was made refer to references [6], mainly based on the history of illness, neurological ex-

Cervical MRI, TCD and BAEP in “isolated” vertigo

Table 1. The overall abnormalities of three examinations between two groups

	Vertigo group	Control group	X ²	P value
cervical MRI (+)	94 (75.20%)	65 (65.00%)	1.08	>0.05
TCD (+)	91 (72.80%)	20 (20.00%)	61.96	<0.01
BAEP (+)	88 (70.40%)	5 (5.00%)	97.99	<0.01

Table 2. The correlations between three kinds of examinations

	Vertigo group	Control group
TCD & cervical MRI	X ² =15.90, p<0.01	X ² =1.10, p>0.05
TCD & BAEP	X ² =17.31, p<0.01	X ² =0.06, p>0.05
BAEP & cervical MRI	X ² =3.01, p>0.05	X ² =0.02, p>0.05

amination and laboratory examination, including electrocardiogram, electronystagmography, electroencephalogram, head CT/MRI, transcranial Doppler (TCD), brain auditory evoked potential (BAEP), and cervical MRI.

Exclusion criteria: Head CT/MRI showed infarction, hemorrhage or tumor involving the posterior fossa circulation, cerebellar lesion (BAEP cannot reflect dysfunction of this situation), visual, vestibular (inner ear), cardiac vertigo, benign paroxysmal positional vertigo, seizures, infection or inflammatory demyelinating vertigo, poison and drug induced vertigo, head and neck trauma. All patients had no other positive signs during neurological examination.

Examination procedure

Cervical MRI, TCD and BAEP were performed in 125 patients with “isolated” vertigo and 100 healthy controls, and then compared results between two groups. Cervical MR images were acquired on a 3.0 T MR scanner (Siemens, Germany). Conventional turbo spin echo T1-and T2-weighted sagittal and axial images, and diffusion tensor imaging were obtained. TCD testing was conducted using EME, TCD-2000 and with a bidirectional, handheld 2-MHz probe. Mean flow velocity (MFV) (cm/s) and pulsatility index (PI) of anterior cerebral arteries, middle cerebral arteries, posterior cerebral arteries, vertebral arteries (VA), and basilar artery (BA) were recorded. The BAEP recording was done with Dantenc Keypoint recording by electrode

Cz according to 10-20 leads international system, using the following settings: alternating clicks of 100 μ s duration, stimulation rate at 10Hz, stimulate intensity at 60 dB. The absolute latency and amplitude of waves I, III, V, and interpeak latency (IPL) of I-III, III-V, I-V were respectively noted.

Statistical analysis

Qualitative data was analyzed by chi-square test. Nonparametric classification data was analyzed by rank sum test. Quantitative data was analyzed by t-test. The Pearson correlation coefficient was used to assess linear relationship. In all the statistical analysis, $\alpha = 0.05$ was set, and $P < 0.05$ was regarded as statistical difference. The SPSS version 21.0 package for windows was used for the statistical data analysis.

Result

Overall abnormalities of three examinations

The overall abnormalities of three examinations were shown in **Table 1**. The results showed significant differences of TCD and BAEP between two groups, but no statistical difference of cervical MRI between two groups (chi-square test).

The correlation analysis was performed respectively between three kinds of examinations (chi-square test, **Table 2**). Comparison within vertigo group showed statistical significance correlation not only between TCD and cervical MRI, but also between TCD and BAEP, but no correlation between cervical MRI and BAEP. No correlation was noted within control group.

Cervical MRI

In vertigo group, cervical MRI results showed normality in 31 cases, cervical curvature abnormality in 12 cases, intervertebral space narrowing in 9 cases, cervical disk bulging in 61 cases, and cervical disk herniation in 12 cases. In control group, cervical MRI results showed normality in 35 cases, cervical curvature abnormality in 65 cases. There was significant difference of cervical MRI severity scale between two groups (rank sum test, $Z = -8.71$, $P < 0.01$).

Table 3. MFV and PI between two groups

	Vertigo group	Control group	t value	P value
LVA MFV	24.36±8.73	35.23±5.87	-11.12	P<0.01
LVA PI	0.91±0.19	0.74±0.10	8.45	P<0.01
RVA MFV	27.15±15.78	33.71±5.21	-4.36	P<0.01
RVA PI	0.86±0.20	0.75±0.08	5.58	P<0.01
BA MFV	36.38±12.89	40.02±7.08	-2.69	P<0.01
BA PI	0.88±0.17	0.72±0.11	8.48	P<0.01

Table 4. BAEP latency and IPL between vertigo and control groups

		Vertigo group (ms)	Control group (ms)	t value	P value
Left	I	1.54±0.23	1.41±0.11	5.27	P<0.01
	III	3.76±0.23	3.62±0.18	4.98	P<0.01
	V	5.64±0.30	5.48±0.22	4.68	P<0.01
	I-III	2.22±0.21	2.21±0.16	0.47	P>0.05
	III-V	1.88±0.24	1.86±0.23	0.77	P>0.05
	I-V	4.11±0.26	4.07±0.21	1.22	P>0.05
Right	I	1.50±0.15	1.44±0.14	2.99	P<0.01
	III	3.71±0.21	3.62±0.17	3.36	P<0.01
	V	5.59±0.24	5.55±0.18	1.31	P>0.05
	I-	2.21±0.197	2.18±0.14	1.28	P>0.05
	III-V	1.88±0.21	1.93±0.15	-2.10	P<0.05
	I-V	4.09±0.28	4.11±0.21	-0.63	P>0.05

TCD

MFV (cm/s) and PI of TCD were showed in **Table 3**, and there were statistically significant differences between two groups (t-test).

BAEP

The BAEP abnormalities in the VBI group included poor morphology, decreased amplitude and prolonged latency of I, III, or V, and prolonged interpeak latencies (IPL) of I-III, III-V, or I-V, which was made refer to normal and abnormal reference [7]. There were statistically significant differences of I, III, V latency on the left side, and also I, III latency and III-V IPL on the right side between two groups (t-test), which were shown in **Table 4**.

Correlation between TCD and BAEP

Within vertigo group there was positive linear correlation between LV PI and I ($r = 0.34$, $P<0.01$), III ($r = 0.22$, $P<0.05$) latency, III-V IPL ($r = -0.20$, $P<0.05$), I-V IPL ($r = -0.29$, $P<0.01$) on

the left side, and as well, V latency ($r = -0.24$, $P<0.01$), III-V IPL ($r = -0.21$, $P<0.05$), I-V IPL ($r = -0.24$, $P<0.01$) on the right side. And correlation also existed between RV PI and I ($r = 0.18$, $P<0.05$), III ($r = 0.18$, $P<0.05$) latency, III-V IPL ($r = -0.29$, $P<0.01$), I-V IPL ($r = -0.26$, $P<0.01$) on the left side, and as well, III-V IPL ($r = -0.19$, $P<0.05$) on the right side. Moreover, correlations were detected between BA PI and III-V IPL ($r = -0.29$, $P<0.01$), I-V IPL ($r = -0.28$, $P<0.01$) on the left side. No correlation was noted within the control group.

Discussion

In this study, no significant difference of cervical MRI about overall abnormality was noted between vertigo and control group. It may be attribute to the considerable middle-aged cases, that were to say, high incidence and rejuvenation of patients with cervical spondylosis made two groups both had a high incidence of cervical disease, thus significant difference was not displayed. But considering the grade of cervical MRI, it was severer in vertigo group than control group ($Z = -8.709$, $P<0.01$) in our study. And it suggested that cervical degeneration caused vertigo through not only one way of direct oppression to vertebral artery [8], but ways related to vascular compression, vasospasm, vascular twist, the sympathetic nerve stimulation, and various reasons such as. Previous studies suggest that vascular abnormality of vertebral artery is the most common cause of posterior circulation ischemia vertigo, and cervical hyperplasia is not vital risk factor of posterior circulation ischemia [9], because that, firstly, patients with posterior circulation ischemia have cervical hyperplasia and atherosclerosis simultaneously, so it is unable to ascertain the etiology. Secondly, there is no significant difference of cervical hyperplasia level between patients with and without circulation ischemia in the aged [10], but their vascular risk factors are different. Thirdly, there is significant correlation between flow velocity of vertebral artery and cervical disc degeneration [8, 11, 13]. Lastly, pathological studies showed that atherosclerosis was more often seen at initial segment of vertebral artery, but vertebral artery stenosis or occlusion is not serious at this site. Clinically, it is common to see patients with seri-

ous cervical hyperplasia but no vertigo, and it needs our further studies.

In this study, we saw statistical significance correlation of the overall abnormality between TCD and cervical MRI and between TCD and BAEP within vertigo group. From our results, both cervical MRI and BAEP abnormalities can be predicted in the presence of TCD abnormalities, and we might make a conclusion that TCD is an important method of choice in the diagnosis of vertigo, and a sensitive method for screening vertigo. Olszewski has used TCD in the diagnosis of cervical vertigo. He considered TCD MFV of vertebral artery decreased 15% during positive neck rotation for diagnosis of cervical vertigo. As we know, TCD has superiority in early detection of “isolated” vertigo, small vascular focal, neurological injury, or other conditions that lack of structural damage of head MRI [3]. In a prior study, TCD is more sensitive (96%) than MRI (84%) (MRA) (46%) in early detection of acute small vessel occlusions, specifically if it is conducted with transcranial color-coded duplex ultrasonography to visualize arteries, and the entire artery starting from its origin is examined. And TCD can be used to differentiate vascular or inner ear focal [14]. Navarros et al conducted a systematic review of literature from 1982 to 2005 to evaluate the precision of TCD compared to MRA. They found that TCD has high sensitivity (92%-100%) and specificity (92%-97%) in the diagnosis of transient ischemic attack. A prior study performed TCD monitoring of the basilar arteries of patients with acute posterior circulation ischemia and found that there was an independent association between microembolic signals and the presence of an intracranial vertebrobasilar stenosis [15, 16]. It suggested that the microembolic of posterior circulation during TCD predicted the occurrence of stroke in that area consequently if no intervention was given. So TCD should be used in primary prevention of posterior circulation stroke after attack of vertigo.

Within vertigo group, in addition to the quantitative correlation between TCD and BAEP, especially TCD (+) BAEP (+) reaching 72.7%, our results also showed significant qualitative correlation between LVA PI and I, III latency, III -V, I-V IPL on the left side, and V latency, III-V, I-V IPL on the right side. And a correlation also exists between RVA PI and I, III latency, III -V, I-V

IPL on the left side, and III-V IPL on the right side. And also between BA PI and III-V, I-V IPL on the left side. The findings confirm that TCD and BAEP parameters can reflect blood supply state and nerve function of the brainstem respectively, and thus can distinguish vertigo of vertebrobasilar origin from peripheral origin. It indicated that if a patient with “isolated” vertigo has abnormal results of TCD, we should consider of abnormal BAEP outcomes, vice versa, if a patient with “isolated” vertigo has abnormal results of BAEP, we should consider of abnormal TCD outcomes. These results are consistent with alien authors, such as Enass et al [14], who believe that both TCD and BAEP are complementary to each other and that their combined use could increase the accuracy in differentiating vertigo of vertebrobasilar origin from peripheral or non-vertebrobasilar origin and prevent the risk of vertebrobasilar stroke. Thus TCD and BAEP measures should be considered in cases with vertigo, and when considering vertebrobasilar vertigo, TCD should be the first examination. On the contrary, when non-vertebrobasilar vertigo is considered, the combination of cervical MRI, TCD and BAEP has superiorities to rule out vertebrobasilar insufficiency for their negative correlations [14, 17].

Additionally, our results showed that the overall abnormality of BAEP was 70.40% in vertigo group, while only 5% in control group. It may suggested that false positive rate of BAEP is lower than the other two. BAEP can be used to objectively distinguish between vertigo of vertebrobasilar origin versus peripheral origin [3, 18-22]. The absence of head MRI abnormality in such patients with abnormal BAEP may suggest microvascular ischemia that was below the threshold for detection on imaging [15], but the membrane potential anomaly has occurred. Furthermore, BAEP can objectively evaluate the degree of vascular lesion to classify vertebrobasilar artery insufficiency [14]. Prior study found that, transient abnormal BAEP could be observed in patients with TIA during ischemia subsiding period, and it further explained the continuity between the vertebral basilar artery ischemia and infarction. From **Table 4** we can see that absolute latencies of wave V on the right side between two groups were not statistically different, but there was significant difference of III-V interpeak latency. Considering of anatomy factors, the upper part of pons is

mainly supplied by the short circumflex branch of pontine arteries, and they are from the basilar artery with a right angle or obtuse angle, which are small, the upper part of pons is more susceptible to ischemia than the lower part, so III-V IPL prolonged over I-III [14], and III-V/I-III>1. And when vertebrobasilar artery insufficiency leads to auditory pathway in ischemia, V latency prolongs earlier than the others, or poor morphology is observed. Animal experiments have proved that, when unilateral vertebral artery was clipped, V latency would prolong more obviously than I, III [18]. Previous studies not only are consistent with ours, but also provided academic basis for the correlation between TCD and BAEP of our results.

Our study had several limitations. First, the number of patients in our study was relatively small. Second, we did not evaluate some vascular risk factors, including tobacco smoking, diabetes, hypertension, and so on. Third, it was not a random control study, which might cause some clinical bias. We should point out that, image changes, pathological results, and a long term follow-up should be further needed to support the conclusions of our study, and to overcome inherent defects of cross-sectional study. However, we believe that, with the development of clinical medicine and update of auxiliary examination technology [23-25], we will get further understanding of vertigo, and explore new approaches for treatment of vertigo.

Disclosure of conflict of interest

None.

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